REMARKS

Claims 19-36 are pending in this application. By this Amendment, claim 34 is amended to overcome a claim objection. No new matter is added by this Amendment.

I.   Specification

The Patent Office objected to the reaction illustrated on page 3, line 23 of the specification ("the Reaction") because (1) the reaction mechanism is allegedly unclear and (2) it is allegedly unclear how the final product results from the shown reactants. See Office Action, page 2.

The Reaction does not illustrate the detailed mechanism for the reaction recited in claim 19. The Reaction illustrates the formation of a diol (designated in the Reaction as "(1)") by the transesterification reaction of α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) (i.e., a PHB diol and designated in the Reaction as "(2)") with diglycolide (designated in the Reaction as "(3)") in the presence of a dibutyltin laureate catalyst. The Reaction is described in detail at paragraph [0012] of the specification. Based upon these descriptions, Applicant submits that one having ordinary skill in the art would understand this reaction mechanism and the final products formed by these reactants.

Withdrawal of the objection is requested.

II.   Claim Objections

A.   Claims 19, 20 And 32-34

The Patent Office objected to claims 19, 20 and 32-34 because the terms "oligo", "stat", "alt" and "ran" appear in the chemical names defined in the specification and claims.

Applicant submits that one having ordinary skill in the art would understand the meaning of the terms "oligo", "stat", "alt" and "ran" and that these terms are widely used and accepted in polymer nomenclature. Specifically, the term "oligo" means a few and the number of repeating units is generally in the range of 10 to 30. The term "stat" designates a

copolymer in which the distribution of monomeric units obeys known statistical laws.

Furthermore, the term "alt" designates a copolymer comprising two species of monomeric

units in an alternating sequence. Also, the term "ran" identifies a copolymer having a

sequence distribution of monomeric units following Bernoullian statistics.

In support of the above contentions, Applicant submits pages from the alphabetical

index of IUPAC Gold book and an excerpt from a publication from the Royal Chemical

Society (particularly the table on page 370) to confirm that one having ordinary skill in the art

would understand the meanings of these notations.

Withdrawal of the objections to the claims is requested.

B.   Claim 34

The Patent Office objected to claim 34 as allegedly containing a typographical error.

Applicant has amended claim 34 in accordance with the Patent Office's suggestion.

Withdrawal of the objection is requested.

C.   Conclusion

In view of the above amendment and arguments, Applicant request withdrawal of the

claim objections.

III.   Rejections Under 35 U.S.C. §103(a)

A.   Neuenschwander In View Of Hori

Claims 19-29 and 31-36 were rejected under 35 U.S.C. §103(a) as allegedly being

unpatentable over U.S. Patent No. 5,665,831 ("Neuenschwander") in view of U.S. Patent No.

5,840,811 ("Hori"). Applicant respectfully traverses the rejection.

1.   Claim 19

Claim 19 recites a biocompatible block copolymer having at least two chemically

different block units obtainable by linear polycondensation of (1) a diol with (2) a component

selected from the group consisting of the same diol, an α,ω-dihydroxypolyester and an α,ω-

dihydroxypolyether, (3) in the presence of an additional compound selected from the group consisting of a diisocyanate, a diacid halide and a phosgene, wherein the diol is obtainable by transesterification of α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) with a compound selected from the group consisting of a diglycolide, a dilactide, a caprolactone and mixtures thereof, the α,ω-dihydroxypolyester is obtainable by transesterification of poly-(R)-hydroxyvaleric acid or copolymers thereof with 3-hydroxyvaleric acid with ethylene glycol, and the α,ω-dihydroxypolyether is selected from the group consisting of α,ω-dihydroxypoly(oxytetramethylene), α,ω-dihydroxypoly(oxyethylene) and copolymers of ethylene glycol and propylene glycol.

In other words, the block copolymer recited in claim 19 can be obtained by linear polycondensation of a diol (1) with (2) a further component selected from the group consisting of α,ω-dihydroxypolyester and an α,ω-dihydroxypolyether in the presence of a diisocyanate, diacid halide or phosgene. Linkage of these components results in polyurethanes with diisocyantes, polyesters with diacid halides and polycarbonates with phosgenes.

Furthermore, as described above, the diol (1) can be obtained by the transesterification reaction of α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) (i.e., a PHB diol and designated in the Reaction as "(2)") with a diglycolide (designated in the Reaction as "(3)"), dilactide and caprolactone in the presence of a dibutyltin laureate catalyst.

The present inventors determined that the biocompatible block copolymer and the diol have an exceptionally good biocompatibility. Furthermore, the glycolide, diglycolide and/or dilactide units may be used to control the hydrolytic and biological rate of the degradability of the biocompatible block copolymer recited in claim 19. Furthermore, the incorporation of the

diol recited in claim 19 also influences the rate of degradation for the crystalline component. As such, it is possible to control the degradability of the block copolymers via the crystalline component alone, the amorphous component alone or both components together.

2. Neuenschwander In View Of Hori

The Patent Office admits that Neuenschwander does not describe a diol that is obtainable by transesterification of α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) with a compound selected from the group consisting of a diglycolide, a dilactide, a caprolactone and mixtures thereof, as recited in claim 19. The Patent Office thus introduces Hori as allegedly describing this feature.

Hori describes optically active block polyester copolymers that are formed by two different types of lactones, wherein the first type of lactone is optically active butyrolactone and the second type of lactone is different from the first type of butyrolactone.

However, Hori does not remedy the deficiencies of Neuenschwander. Hori does not describe the diol recited in claim 19. This is confirmed by the fact that because the block copolymer degradation rate (i.e., half-life) described in the Examples of Hori is _different_ from the block copolymer degradation rate described in the Examples of the specification (which embody the biopolymer recited in claim 19). Specifically, the block copolymers according to Hori have a degradation rate in the range of _several weeks_. *See, e.g.*, Example 21, Test Examples 1-8 and Figure 1. However, the degradation rate for the block copolymers of claim 1 is in the range of _several days_. See, Example 4 and Table 1 in paragraphs [0066] to [0071] of the specification, Example 4, Table 3. Because Hori describes a block copolymer with a much higher degradation rate, Hori does not describe the diol recited in claim 19.

As such, Neuenschwander, alone or in combination with Hori, would not have provided one of ordinary skill in the art with any reason or rationale to have derived the block copolymer recited in claim 19 with any reasonable expectation of success.

3.   Conclusion

Withdrawal of the rejection is requested.

B.   Neuenschwander In View Of Tokiwa

Claims 19, 21-29 and 31 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Neuenschwander in view of U.S. Patent No. 5,124,371 ("Tokiwa"). Applicant respectfully traverses the rejection.

The Patent Office admits that Neuenschwander does not describe a diol obtainable by transesterification of α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) with a compound selected from the group consisting of a diglycolide, a dilactide, a caprolactone and mixtures thereof, as recited in claim 19. The Patent Office introduces Tokiwa as allegedly describing this feature.

However, Tokiwa does not remedy the deficiencies of Neuenschwander. Tokiwa describes a plastic composition comprising polycaprolactone, poly-beta-hydroxybutyrate that are partly copolymerized. The resulting blend comprises a polycaprolactone/poly-beta-hydroxybutyrate copolymer in admixture.

As such, Tokiwa merely describes the general reaction of a polycaprolactone with a poly-beta-hydroxybutyrate and does not describe the tranesterification of the specific hydroxybutyrate copolymer (i.e., α,ω-dihydroxy-[oligo(3-(R)-hydroxybutyrate)-ethylene-oligo-3-(R)-hydroxybutyrate) recited in claim 1. As such, one having ordinary skill in the art would have only been provided with a general knowledge that polycaprolactone compounds may copolymerize with hydroxybutyrates. However, that same individual would not have been provided with any reason or rationale from Neuenschwander, alone or in combination with Tokiwa, to have derived the block copolymer recited in claim 19 with any reasonable expectation of success.

Withdrawal of the rejection is requested.

C.   Neuenschwander In View Of Hori Or Tokiwa And In Further View Of Williams

Claim 30 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Neuenschwander in view of Hori or Tokiwa and in further view of U.S. Patent No. 6,548,569 ("Williams"). Applicant respectfully traverses the rejection.

For the reasons discussed above, Neuenschwander, Hori and Tokiwa do not describe the diol recited in claim 19 (from which dependent claim 30 depends). Furthermore, Williams does not remedy the deficiencies of these references. Williams describes biocompatible polyhydroxyalkanoate produced by an enzymatic process using recombinant bacteria. See Williams, the Abstract. One having ordinary skill in the art would have understood that enzymatic production of polymers is a completely different process, and most likely would not have been compatible with a chemical process for preparing copolymers, such as recited in claim 19. Such a conclusion is supported by the disclosure of Williams, which describes that polyhydroxyalkanoates described therein possess a degradation rate much higher (i.e., several weeks) than the diol recited in claim 19.

For at least the above reasons, the combination of Neuenschwander, Hori, Tokiwa and Williams does not render obvious claim 19.

Claim 30 depends from claim 27, which depends from claim 19. For at least its respective dependency, and for the additional features recited, the combination of Neuenschwander, Hori, Tokiwa and Williams also does not render obvious claim 30.

Withdrawal of the rejection is requested.

D.   Conclusion

In view of the foregoing, Applicant respectfully request withdrawal of the 35 U.S.C. §103(a) rejections.

IV. **Double Patenting**

A. **Claims 19 And 30**

Claims 19 and 30 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting as allegedly being unpatentable over claims 1-6 and 10 of co-pending U.S. Patent Application No. 12/303,897 ("the 897 Application"). Applicant respectfully traverses this rejection.

Because the provisional nonstatutory obviousness-type double patenting (ODP) rejection is the only rejection remaining for the reasons discussed above, and the effective filing date of the present application (PCT filed July 6, 2004) is before the earliest effective filing date of the 897 Application (PCT filed June 4, 2007), Applicant respectfully requests the Patent Office to withdraw the rejection and pass the present application to issue. See MPEP §804(I)(B)(1).

Accordingly, withdrawal of the provisional obviousness-type double patenting rejection is respectfully requested.

B. **Claims 19, 20 And 31**

Claims 19, 20 and 31 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting as allegedly being unpatentable over claims 1-6 and 10 of co-pending U.S. Patent Application No. 12/302,995 ("the 995 Application"). Applicant respectfully traverses this rejection.

Because the provisional nonstatutory obviousness-type double patenting (ODP) rejection is the only rejection remaining for the reasons discussed above, and the effective filing date of the present application (PCT filed July 6, 2004) is before the earliest effective filing date of the 995 Application (PCT filed May 30, 2007), Applicant respectfully requests the Patent Office to withdraw the rejection and pass the present application to issue. See MPEP §804(I)(B)(1).

Accordingly, withdrawal of the provisional obviousness-type double patenting rejection is respectfully requested.

V.   Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 19-36 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,

James A. Oliff
Registration No. 27,075

Jeremy D. Tillman
Registration No. 62,639

JAO:JDT/hs

Attachments:
    Alphabetical Listings from IUPAC Gold Book
    Excerpt From Royal Chemical Society Publication

Date: August 3, 2009

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IUPAC > Gold Book > alphabetical index > O > oligo

structure search

PREVIOUS	NEXT
olefins	oligomer

oligo

A prefix meaning 'a few', and used for compounds with a number of repeating units intermediate between those in monomers and those in high polymers. The limits are not precisely defined, and in practice vary with the type of structure being considered, but are generally from 3 to 10, e.g. oligopeptides, oligosaccharides.

Source:

PAC, 1995, 67, 1307 (Glossary of class names of organic compounds and reactivity intermediates based on structure (IUPAC Recommendations 1995)) on page 1353

Interactive Link Maps		
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Version for print | History of this term

IUPAC GOLD BOOK

IUPAC > Gold Book > alphabetical index > S > statistical copolymer

statistical copolymer

A copolymer consisting of macromolecules in which the sequential distribution of the monomeric units obeys known statistical laws.

Note:
An example of a statistical copolymer is one consisting of macromolecules in which the sequential distribution of monomeric units follows Markovian statistics.

Source:
PAC, 1996, 68, 2287 (*Glossary of basic terms in polymer science (IUPAC Recommendations 1996)*) on page 2301

Interactive Link Maps

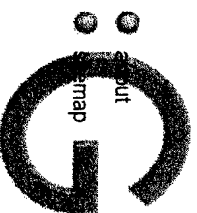| First Level	Second Level	Third Level

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random copolymer

A copolymer consisting of macromolecules in which the probability of finding a given monomeric unit at any given site in the chain is independent of the nature of the adjacent units.

Note:

In a random copolymer, the sequence distribution of monomeric units follows Bernoullian statistics.

Source:

PAC, 1996, *68*, 2287 (*Glossary of basic terms in polymer science (IUPAC Recommendations 1996)*) on page 2301

Interactive Link Maps		
First Level	Second Level	Third Level

IUPAC > Gold Book > alphabetical index > A > **alternating copolymer**

alternating copolymer

A copolymer consisting of macromolecules comprising two species of monomeric units in alternating sequence.

Note:
An alternating copolymer may be considered as a homopolymer derived from an implicit or hypothetical monomer.

See also: homopolymer (1)

Source:
PAC, 1996, 68, 2287 (*Glossary of basic terms in polymer science (IUPAC Recommendations 1996)*) on page 2301

Interactive Link Maps
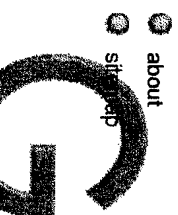
First Level	Second Level	Third Level

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19:   Source-Based Nomenclature for Copolymers

CONTENTS

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Basic concept
Classification and definition of copolymers
   1. Copolymers with an unspecified arrangement of monomeric units
   2. Statistical copolymers
   3. Alternating copolymers
   4. Other types of periodic copolymers
   5. Block copolymers
   6. Graft copolymers
   7. Polymers made by polycondensation or related polymerization
   8. Specification with regard to mass fractions, mole fractions, molar masses and degrees of polymerization
Appendix: alternative nomenclature for copolymers
References

PREAMBLE

Copolymers have gained considerable importance both in scientific research and in industrial applications. A consistent and clearly defined system for naming these polymers would, therefore, be of great utility. The nomenclature proposals presented here are intended to serve this purpose by setting forth a system for designating the types of monomeric-unit sequence arrangements in copolymer molecules.

In principle, a comprehensive structure-based system of naming copolymers would be desirable. However, such a system presupposes a knowledge of the structural identity of all the constitutional units as well as their sequential arrangements within the polymer molecules; this information is rarely available for the synthetic polymers encountered in practice. For this reason, the proposals presented in this Report embody an essentially *source-based nomenclature system.*

Application of this system should not discourage the use of structure-based nomenclature whenever the copolymer structure is fully known and is amenable to treatment by the rules for single-strand polymers [1, 2]. It is intended that the present nomenclature system supersede the previous recommendations published in 1952 [3].

BASIC CONCEPT

The nomenclature system presented here is designed for copolymers. By definition, copolymers are polymers that are derived from more than one species of monomer [4]. Various classes of copolymers are discussed, which are based on the characteristic sequence arrangements of the monomeric units within the copolymer molecules. Generally, the names of monomers are used to specify monomeric units; the latter can be named using the trivial, semi-systematic or systematic form. The classes of copolymers are as follows:

unspecified	Rule 1.1
statistical	Rule 2.1
random	Rule 2.2
alternating	Rule 3.1
periodic	Rule 4.1
block	Rule 5.1
graft	Rule 6.1

In those cases where copolymer molecules can be described by only one species of constitutional unit in a single sequential arrangement, copolymers are regular polymers [4] and can, therefore, be named on a structure basis [1, 2]. Examples will be quoted later in the text.

Polymers having monomeric units differing in constitutional or configurational features, but derived from a single monomer, are not regarded as copolymers, in accordance with the basic definitions [4]. Examples of such polymers, which are not copolymers, are:

(1) polybutadiene with mixed sequences of 1,2- and 1,4-units; (2) poly(methyloxirane), also known as poly(propylene oxide), obtained through polymerization of a mixture of the two enantiomers, R and S, and containing both R and S monomeric units.

The nomenclature system presented here can, however, also be applied to such pseudo-copolymers. Polymers having monomeric units differing in constitutional features, but derived from a homopolymer by chemical modification, can be named in the same way, e.g.,

(3) partially hydrolysed poly(vinyl acetate) containing both ester and alcohol units.

CLASSIFICATION AND DEFINITION OF COPOLYMERS

A systematic source-based nomenclature for copolymers must identify the constituent monomers and provide a description of the sequence arrangement of the different types of monomeric units present. According to the present proposals, these objectives are achieved by citing the names of the constituent monomers after the prefix 'poly', and by placing between the names of each pair of monomers an italicized connective to denote the kind of arrangement by which those two types of monomeric units are related in the structure. Seven types of sequence arrangement are listed below, together with the corresponding connectives and examples, in which A, B and C represent the names of monomers.

NOMENCLATURE

Type	Connective	Example
unspecified	-co-	poly(A-*co*-B)
statistical	-stat-	poly(A-*stat*-B)
random	-ran-	poly(A-*ran*-B)
alternating	-alt-	poly(A-*alt*-B)
periodic	-per-	poly(A-*per*-B-*per*-C)
block	-block-	polyA-*block*-polyB
graft	-graft-	polyA-*graft*-polyB

Each of these types of copolymer is considered in more detail below. When the chemical nature of the end groups is to be specified, the name of the copolymer (as described above) is preceded by the systematic names of the terminal units. The prefix α or ω refers to the terminal unit attached to the left or right, respectively, of the structure, as written.

Example:

α-X-ω-Y-poly(A-*co*-B).

The citation of A, B and C is not intended to reflect an order of seniority, unless such seniority is specified in the rules. As a result, more than one name is often possible.

1   Copolymers with an unspecified arrangement of monomeric units

Rule 1.1

An unspecified sequence arrangement of monomeric units is represented by

(A-*co*-B)
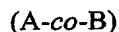
and the corresponding copolymer has the name

poly(A-*co*-B)
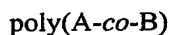
Example: An unspecified copolymer of styrene and methyl methacrylate is named

poly[styrene-*co*-(methyl methacrylate)].

2   Statistical copolymers

Statistical copolymers are copolymers in which the sequential distribution of the monomeric units obeys known statistical laws; e.g. the monomeric-unit sequence distribution may follow Markovian statistics of zeroth (Bernoullian), first, second or a higher order. Kinetically, the elementary processes leading to the formation of a statistical sequence of monomeric units do not necessarily proceed with equal *a priori* probability. These processes can lead to various types of sequence distribution comprising those in which the arrangement of monomeric units tends towards alternation, tends towards

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clustering of like units, or exhibits no ordering tendency at all [5]. In simple binary copolymerization, the nature of this sequence distribution can be indicated by the numerical value of a function either of the reactivity ratios or of the related run number [5, 6].

The term statistical copolymer is proposed here to embrace a large proportion of those copolymers that are prepared by simultaneous polymerization of two or more monomers in admixture. Such copolymers are often described in the literature as 'random copolymers', but this is almost always an improper use of the term random and such practice should be abandoned.

Rule 2.1

A statistical sequence arrangement of monomeric units is represented by

(A-*stat*-B), (A-*stat*-B-*stat*-C), etc.

where -*stat*- indicates that the statistical sequence distribution with regard to A, B, C, etc, units is considered to be known. Statistical copolymers are named

poly(A-*stat*-B), poly(A-*stat*-B-*stat*-C), etc.

Examples:

poly(styrene-*stat*-butadiene)

poly(styrene-*stat*-acrylonitrile-*stat*-butadiene)

Random copolymers. A random copolymer is a special case of a statistical copolymer. It is a statistical copolymer in which the probability of finding a given monomeric unit at any given site in the chain is independent of the nature of the neighbouring units at that position (Bernoullian distribution). In other words, for such a copolymer, the probability of finding a sequence ...ABC... of monomeric units A, B, C..., i.e. $P(...ABC...]$, is given by

$$P[...ABC...] \quad = \quad P[A] \cdot P[B] \cdot P[C] \quad = \quad \prod_{i=A,B,C} P[i]$$

where $P[A]$, $P[B]$, $P[C]$, etc. are the unconditional probabilities of the occurrence of various monomeric units. As already noted above, the term 'random' should not be used for statistical copolymers except in this narrow sense.

Some authors use the term 'random' to denote the Bernoullian case further restricted by the condition that the monomeric units be present in exactly equal amounts [7].

Rule 2.2

A random sequence arrangement of monomeric units is represented by

(A-*ran*-B), (A-*ran*-B-*ran*-C), etc.

where -*ran*- indicates a random sequence distribution with regard to A, B, C, etc, units. Random copolymers are named

poly(A-*ran*-B), poly(A-*ran*-B-*ran*-C), etc.

Example:

poly[ethene-*ran*-(vinyl acetate)]

3 Alternating copolymers

An alternating copolymer is a copolymer comprising two species of monomeric units distributed in alternating sequence. The arrangement

-ABABABAB-   or   (AB)$_n$

thus represents an alternating copolymer.

Rule 3.1

An alternating sequence arrangement of monomeric units is represented by

(A-*alt*-B)

and the corresponding alternating copolymer is named

poly(A-alt-B).

Example:

poly(styrene-*alt*-(maleic anhydride)]

Alternating sequence arrangements can form constitutionally regular structures and may, in those cases, also be named utilizing the structure-based nomenclature for regular single-strand organic polymers. The example above would be then named

poly[(2,5-dioxotetrahydrofuran-3,4-diyl)(1-phenylethane-1,2-diyl)]

4 Other types of periodic copolymers

In addition to alternating polymers, other structures are known in which the monomeric units appear in an ordered sequence. Examples are:

-ABCABCABC-   or   (ABC)$_n$
-ABBABBABB-   or   (ABB)$_n$
-AABBAABBAABB-   or   (AABB)$_n$
-ABACABACABAC-   or   (ABAC)$_n$

Rule 4.1

A periodic sequence arrangement of monomeric units is represented by

(A-*per*-B-*per*-C)
(A-*per*-B-*per*-B)
(A-*per*-A-*per*-B-*per*-B)
(A-*per*-B-*per*-A-*per*-C), etc.

and the corresponding periodic copolymers are named

poly(A-*per*-B-*per*-C)
poly(A-*per*-B-*per*-B)
poly(A-*per*-A-*per*-B-*per*-B)
poly(A-*per*-B-*per*-A-*per*-C), etc, respectively.

If these polymers are regular. they can also be named according to the structure-based nomenclature for regular single-strand organic polymers [1].

Example: The binary monomer mixture consisting of formaldehyde and ethylene oxide might yield the periodically sequenced copolymer

$$-\!\!\!\left(\!CH_2\!-\!O\!-\!CH_2\!-\!CH_2\!-\!O\!-\!CH_2\!-\!CH_2\!-\!O\!\right)_{\!n}$$
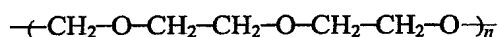
which is named

poly[formaldehyde-*per*-(ethylene oxide)-*per*-(ethylene oxide)]
or
poly[formaldehyde-*alt*-bis(ethylene oxide)]

or, alternatively,
poly(oxymethyleneoxyethyleneoxyethylene).

Rule 4.2
If copolymer structures comprise several types of periodic sites, only some of which are always occupied by particular species of monomeric units (A, B...), and sites of the other types are occupied by two or more types of monomeric unit (U, V...) in irregular arrangement, the names of the monomers in the latter sites are embraced by parentheses and are separated by semicolon(s).

Examples:

1. The copolymer with the sequence arrangement

    -AUAVAVAUAVAUAU- is named poly[A-*alt*-(U;V)].

2. The copolymer with the sequence arrangement

    -AUBUAVBUAVBVAUBVAUBU- is named poly[A-*per*-(U;V)-*per*-B-*per*-(U;V)].

5   Block copolymers
A block polymer is a polymer comprising molecules in which there is a linear arrangement of blocks, a block being defined as a portion of a polymer molecule in which the monomeric units have at least one constitutional or configurational feature absent from the adjacent portions [4]. In a block copolymer, the distinguishing feature is constitutional, i.e. each of the blocks comprises units derived from a characteristic species of monomer.

NOMENCLATURE

In the sequence arrangements

    -AAAAAAAA-BBBBBBBBBBB-
    -AAAAAAAA-BBBBBBBBBBB-AAAAAAAA-
    -AABABAAABB-AAAAAAAA-BBBBBBBBBBB-

the sequences -AAAAAAAA-, -BBBBBBBBBBB- and -AABABAAABB- are blocks.

Rule 5.1

A block sequence arrangement is represented by A_k-*block*-B_m, A_k-*block*-(A-*stat*-B), etc. and the corresponding polymers are named

polyA-*block*-polyB, polyA-*block*-poly(A-*stat*-B), etc., respectively.

If no ambiguity arises, a long dash may be used to designate block connections, as follows:

    polyA—polyB.

For complex cases, use of -*block*- rather than the long dash is always encouraged. The order of citation of the block names corresponds to the order of succession of the blocks in the chain as written from left to right.

Examples: In the following examples, the subscripts k, m, ...represent different multiplicity of the monomeric units for different blocks. They may be indeterminate or specific (see *Rule* 5.3). In each case, the first line gives a representation of the block sequence arrangement, the second the corresponding name and the third an illustration of a specific case.

    A_k-*block*-B_m
    polyA-*block*-polyB
    polystyrene-*block*-polybutadiene

    A_k-*block*-B_m-*block*-A_k
    polyA-*block*-polyB-*block*-poly A
    polystyrene-*block*-polybutadiene-*block*-polystyrene

    (A-*stat*-B)-*block*-A_k-*block*-B_m
    poly(A-*stat*-B)-*block*-polyA-*block*-polyB
    poly(styrene-*stat*-butadiene)-*block*-polystyrene-*block*-polybutadiene
    A_k-*block*-B_n-*block*-C_m
    polyA-*block*-polyB-*block*-polyC
    polystyrene-*block*-polybutadiene-*block*-poly(methyl methacrylate)

Rule 5.2

Where a succession of blocks, such as -A_k-B_n-C_m- is repeated, the appropriate multiplying prefix is used.

Examples:

    (A_k-*block*-B_n-*block*-C_m)₃
    tris(polyA-*block*-polyB-*block*-polyC)

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$(A_k\text{-}block\text{-}B_n\text{-}block\text{-}C_m)_p$
poly(polyA-*block*-polyB-*block*-polyC).

Rule 5.3

When it is possible to specify the chain length of a block, the appropriate Greek prefix (e.g. hecta for 100) may be used rather than poly. Although short sequence lengths are not strictly embraced within the definition of 'block', the same device may usefully be employed by using the general prefix 'oligo' or the appropriate specific prefix (e.g. tri).

Examples:

$A_c\text{-}block\text{-}B_8$
oligoA-*block*-octaB
$(A_c\text{-}block\text{-}B_k\text{-}block\text{-}C_3)_n$
poly(oligoA-*block*-polyB-*block*-triC)
$(A_c\text{-}block\text{-}B_k)_4$
tetrakis(oligoA-*block*-poly B)

where c is a small integer corresponding to the degree of polymerization of the oligomeric sequence.

Rule 5.4

Those block copolymers, derived from more than two monomers, that also exhibit statistical block sequence arrangements are named according to the principles of *Rule* 2.1.

Example: The statistical sequence arrangement

$-A_k\text{-}block\text{-}B_m\text{-}block\text{-}C_n\text{-}block\text{-}B_m\text{-}block\text{-}A_k\text{-}block\text{-}C_n-$

is named poly(polyA-*stat*-polyB-*stat*-polyC).

Rule 5.5

In the name of block copolymers with blocks connected by way of junction units, X, that are not part of the blocks, the name of the junction unit is inserted in the appropriate place. The connective, -*block*-, may be omitted. Thus,

$A_k\text{-}block\text{-}X\text{-}block\text{-}C_m$ or $A_k\text{-}X\text{-}C_m$

is named polyA-*block*-X-*block*-polyC or polyA—X—polyC.

The same designations can be applied to block polymers.

Examples:

polystyrene-*block*-dimethylsilanediyl-*block*-polybutadiene
or
polystyrene—dimethylsilanediyl—polybutadiene

and

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polystyrene-*block*-dimethylsilanediyl-*block*-polystyrene
or
polystyrene—dimethylsilanediyl—polystyrene.

Rule 5.6

A block copolymer wherein A_k and B_m blocks, connected through junctions X, are distributed in statistical manner in the polymer molecules, as in

-A_k-*block*-X-*block*-B_m-*block*-X-*block*-B_m-*block*-X-*block*-A_k-

is named poly[(polyA-*block*-X)-*stat*-(polyB-*block*-X)].

A block copolymer wherein A_k and B_m blocks and junction units X are all distributed in statistical manner, as in

-A_k-*block*-X-*block*-B_m-*block*-A_k-*block*-B_m-*block*-X-*block*-B_m-*block*-X-*block*-A_k-

is named poly(polyA-*stat*-X-*stat*-polyB).

6   Graft copolymers

A graft polymer is a polymer comprising molecules with one or more species of block connected to the main chain as side chains, these side chains having constitutional or configurational features that differ from those in the main chain [4]. In a graft copolymer the distinguishing feature of the side chains is constitutional, i.e. the side chains comprise units derived from at least one species of monomer different from those which supply the units of the main chain.

Rule 6.1

The simplest case of a graft copolymer can be represented by A_k-*graft*-B_m or the arrangement

```
--AAAAAAAAAAAAAAAAA--
          |
          B
          B
          B
          B
          B
          B
```
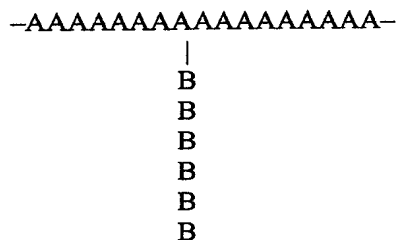
and the corresponding name is polyA-*graft*-polyB where the monomer named first (A in this case) is that which supplied the backbone (main chain) units, while that named second (B) is in the side chain(s).

Examples:
Each of the following examples presents in order, a representation of the graft sequence arrangement, the corresponding name and an illustration of a specific case.

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1. A_k-*graft*-B_m

polyA-*graft*-polyB

polybutadiene-*graft*-polystyrene
(polystyrene grafted to polybutadiene)

2. $(A_k$-*block*-$B_m)$-*graft*-C_n

(polyA-*block*-polyB)-*graft*-polyC

(polybutadiene-*block*-polystyrene)-*graft*-polyacrylonitrile
(polyacrylonitrile grafted to a polybutadiene-polystyrene block copolymer at unspecified sites)

3. (A-*stat*-B)-*graft*-C_n

poly(A-*stat*-B)-*graft*-polyC

poly(butadiene-*stat*-styrene)-*graft*-polyacrylonitrile
(polyacrylonitrile grafted to a statistical butadiene-styrene copolymer at unspecified sites)

4. A_k-*block*-$(B_m$-*graft*-$C_n)$

polyA-*block*-(polyB-*graft*-polyC) or (polyB-*graft*-polyC)-*block*-polyA

polybutadiene-*block*-(polystyrene-*graft*-polyacrylonitrile) or
(polystyrene-*graft*-polyacrylonitrile)-*block*-polybutadiene
(polystyrene-polybutadiene block copolymer with polyacrylonitrile grafted to the polystyrene block)

5. $[A_k$-*graft*-(B-*co*-C)]-*block*-B_m

[polyA-*graft*-poly(B-*co*-C)]-*block*-polyB or polyB-*block*-[polyA-*graft*-poly(B-*co*-C)]

[polybutadiene-*graft*-poly(styrene-*co*-acrylonitrile)]-*block*-polystyrene or
polystyrene-*block*-[polybutadiene-*graft*-poly(styrene-*co*-acrylonitrile)]
(polybutadiene-polystyrene block copolymer with a styrene-acrylonitrile copolymer with an unspecified sequence arrangement of monomeric units grafted to the polybutadiene block).

Rule 6.2
If more than one type of graft chain is attached to the backbone, semicolons are used to separate the names of the grafts or their symbolic representations.

Example:

A_k-*graft*-$(B_m$; $C_n)$
polyA-*graft*-(polyB; polyC)

polybutadiene-*graft*-[polystyrene; poly(methyl methacrylate)]
(polystyrene and poly(methyl methacrylate) chains grafted to a polybutadiene backbone).

Rule 6.3

Graft copolymers with known numbers of graft chains are named using numeric prefixes (mono, bis, tris, etc).

Example:

$A_k(-graft-B_m)_3$

polyA-tris(-*graft*-polyB)

polybutadiene-tris(-*graft*-polystyrene)
(three polystyrene grafts per polybutadiene backbone).

If the precise site of grafting is known, it can be specified.

Example:

A_{10}-*block*-(X-*graft*-B_m)-*block*-A_{15}

decaA-*block*-(X-*graft*-poly B)-*block*-pentadecaA

decabutadiene-*block*-(methylsilanetriyl-*graft*-polystyrene)-*block*-pentadecabutadiene.

The system of naming graft copolymers is also applicable, in principle, to 'star copolymers' [*], where chains having different constitutional or configurational features are linked through a central moiety.

Examples:

1. A_k-*block*-[X-(*graft*-B_m)$_2$]-*block*-A_k or B_m-*block*-[X-(*graft*-A_k)$_2$]-*block*-B_m

   polyA-*block*-[X-bis(-*graft*-polyB)]-*block*-polyA or
   polyB-*block*-[X-bis(-*graft*-polyA)]-*block*-polyB

   polystyrene-*block*-[silanetetraylbis(-*graft*-polybutadiene)]-*block*-polystyrene or
   polybutadiene-*block*-[silanetetraylbis(-*graft*-polystyrene)]-*block*-polybutadiene
   (two polystyrene and two polybutadiene chains attached to a central Si atom)

2. A_k-*block*-[X-*graft*-(B_m; C_n)]-*block*-D_p

   polyA-*block*-[X-*graft*-poly B; polyC)]-*block*-polyD
   polystyrene-*block*-[silanetetrayl-*graft*-(polybutadiene;
   polyisoprene)]-*block*-poly(methyl methacrylate)

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* Footnote for the Second Edition: Star copolymers can be named by using the prefix '*star-*' as in *star-*(polyA; ;poly: B; polyC) (see Chapter 20).

(a polybutadiene chain, a polyisoprene chain, a polystyrene chain and a poly(methyl methacrylate) chain attached to the same central Si atom).

In the absence of a seniority rule, several other names are possible.

7   Polymers made by polycondensation or related polymerization

The nomenclature system for copolymers is also applicable to polymers made by polycondensation of more than one monomeric species, or, more generally, by polymerization of more than one monomeric species where molecules of all sizes (i.e. monomers, oligomers, polymers) can react with each other. One can distinguish the case of polymers made by polycondensation of homopolymerizable monomers from that of polymers made by polycondensation of complementary ingredients that do not usually separately homopolymerize. Rigorous application of the source-based definition of a copolymer [4] embraces polymers such as poly(ethylene terephthalate) or poly(hexane-1,6-diyladipamide)* (which are commonly regarded as homopolymers) because two ingredients are, in each case, the usual starting materials of polymerization. If polymers of this type have constitutionally regular structures and are regular polymers, the nomenclature for regular single-strand organic polymers can also be used [1].

This applies, for example, to the polymer derived from terephthalic acid and ethylene glycol, which by source-based copolymer nomenclature would be named as poly[(ethylene glycol)-*alt*-(terephthalic acid)], if in fact the polymer has been prepared by a polycondensation starting with terephthalic acid and ethylene glycol. However, if the starting material is the partial ester, $HOCH_2CH_2OCOC_6H_4COOH$, the appropriate source-based name is that of a homopolymer, whereas use of the starting material bis(2-hydroxyethyl) terephthalate, $HOCH_2CH_2OCOC_6H_4COOCH_2CH_2OH$, extensively used industrially, would suggest the name poly[bis(2-hydroxyethyl) terephthalate]. Regardless of the starting materials used, the structure-based name is poly(oxyethyleneoxy-terephthaloyl). The traditional name poly(ethylene terephthalate) is also permitted, because it is so well established in the literature.

For all such polymers made by polycondensation of two complementary difunctional ingredients (or 'monomers'), which can readily be visualized as reacting on a 1:1 basis to give an 'implicit monomer', the homopolymerization of which would give the actual product, the structure-based nomenclature may be suitable insofar as such a polymer is regular and can be represented as possessing a single constitutional repeating unit. It is to be noted that this is applicable only to cases where the mole ratio of the ingredients is 1:1 and the ingredients are exclusively difunctional.

The introduction of a third component into the reaction system necessitates the use of copolymer nomenclature which can logically be developed from the foregoing rules, as the examples below illustrate. The copolymer derived from reaction of ethylene glycol with a mixture of terephthalic and isophthalic acids would be named:

poly{[(ethylene glycol)-*alt*-(terephthalic acid)]-*co*-[(ethylene glycol)-*alt*-(isophthalic acid)]}, poly[(ethylene terephthalate)-*co*-(ethylene isophthalate)] or
poly[(ethylene glycol)-*alt*-(terephthalic acid; isophthalic acid)]

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* poly(*N*,*N'*-hexane-1,6-diylhexanediamide)

A polymer derived from the polycondensation of a single actual monomer, the molecules of which terminate in two different complementary functional groups (e.g. 6-aminohexanoic acid) is, by definition, a (regular) homopolymer. When two different monomers of this type react together, the product is a copolymer that can be named in appropriate fashion. For example, if 6-aminohexanoic acid is copolycondensed with 7-aminoheptanoic acid, leading to a statistical distribution of monomeric units, the product is named poly[(6-aminohexanoic acid)-stat-(7-aminoheptanoic acid)].

8 Specification with regard to mass fractions, mole fractions, molar masses and degrees of polymerization

Whereas subscripts placed immediately after the formula of the monomeric unit or the block designate the degree of polymerization or repetition, mass and mole fractions and molar masses — which in most cases are average quantities — may be expressed by placing corresponding figures after the complete name or symbol of the copolymer. The order of citation is the same as for the monomer species in the name or symbol of the copolymer. Unknown quantities can be designated by a, b, etc.

Although this scheme can be extended to complicated cases, it is recommended that its application be restricted to simple cases; any treatment of more complicated systems should be explained in the text.

Rule 8.1

Mass fractions, or mass percentages, for the monomeric units are placed in parentheses after the copolymer name, followed by the symbol 'w', or the phrase 'mass %', respectively. The order of citation in the parentheses is the same as in the name.

Examples:

1. polybutadiene-*graft*-polystyrene (0.75:0.25 w) or polybutadiene-*graft*-polystyrene (75:25 mass %) (a graft copolymer containing 75 mass % of polybutadiene and 25 mass % of grafted polystyrene)

2. polybutadiene-*graft*-poly(styrene-*stat*-acrylonitrile) (0.75:a:b w) or polybutadiene-*graft*-poly(styrene-*stat*-acrylonitrile) (75:a:b mass %) (a graft copolymer containing 75 mass % of butadiene units as backbone and unknown quantities in statistical arrangement of styrene and acrylonitrile units in the grafted chains).

Rule 8.2

Mole fractions, or mole percentages, for the monomeric units are placed in parentheses after the copolymer name, followed by the symbol 'x', or the phrase 'mol %', respectively. The order of citation in the parentheses is the same as in the name.

Example:

polybutadiene-*graft*-polystyrene (0.85:0.15 x) or
polybutadiene-*graft*-polystyrene (85:15 mol %)
(a graft copolymer containing 85 mol % of butadiene units and 15 mol % of styrene units).

Rule 8.3

The molar mass, relative molecular mass or degree of polymerization may be included in the scheme of *Rules* 8.1 and 8.2 by adding the corresponding figures, followed by the symbol M, M_r or DP, respectively.

Examples:

1. polybutadiene-*graft*-polystyrene (75:25 mass %; 90 000:30 000 M_r) (a graft copolymer consisting of 75 mass % of butadiene units with a relative molecular mass of 90 000 as the backbone, and 25 mass % of styrene units in grafted chains with a relative molecular mass of 30 000)

2. polybutadiene-*graft*-polystyrene (1700:290 DP) (a graft copolymer consisting of a polybutadiene backbone with a degree of polymerization of 1700 to which polystyrene with a degree of polymerization of 290 is grafted)

APPENDIX: ALTERNATIVE NOMENCLATURE FOR COPOLYMERS

In the first edition of this book, an alternative nomenclature system was described, which was based on the principle that a copolymer can be described by the prefix 'copoly' followed by citation of the names of the monomers as copoly(A/B), copoly(A/B/C), etc., where A, B and C represent the names of the monomers employed. However, after two decades this system has been scarcely adopted for copolymer naming in the literature, the appendix is therefore omitted from this book.

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